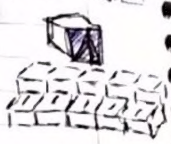
Ex: number of coil = 48 , P = 4 poles, Lab winding each coil has 10 turns each turn has a Resistance Value with 0.01 Ω , simplex

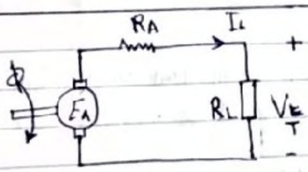


- 48 coil - 10 turns/coil - $R_{turn} = 0.01\ \Omega$
- 4 poles
- Lab → $a = mP = (1)(4) = 4$ Paths
- simplex → m = 1

$R_{coil} = 10 \times 0.01 = \boxed{0.1\ \Omega}$, $R_{path} = 12 \times 0.1 = \boxed{1.2\ \Omega}$

48/4 = 12 coil/path

$1/R_{eq} = \frac{1}{1.2} + \frac{1}{1.2} + \frac{1}{1.2} + \frac{1}{1.2} = \frac{4}{1.2}$, $\boxed{R_{eq\,Arm} = \frac{1.2}{4}} = \frac{R_{path}}{no\ path}$



ϕ_{flux} = Wb or V/s
الوحدة ويبر

W: Speed (rad/s), it need to be in rpm
$n_{rmp} = \boxed{\frac{n\,2\pi}{60}}$ (rad/s)

$\boxed{E = K\phi W}$

K: mechanical constant
$\boxed{K = \frac{ZP}{2\pi a}}$, Z = 2CN , P = num of Poles

E: enduced voltage

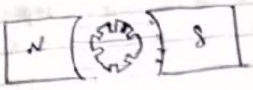
$\boxed{V_T = E_A - I_A R_A}$

* الحمل متغير فلازم أغير E_A عشان يظل V_T ثابت
* E_A بتتغير عن طريقتين إما ϕ أو W

V_T: Terminant Voltage

Voltage Regulation DC-Generator

$\boxed{V_R = \frac{E_A - V_T}{V_T} * 100\ \%}$



[P]: number of Poles [even]

[C]: number of coils

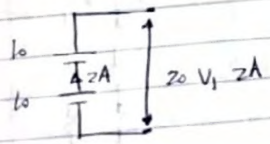
[N_c]: number of turn per coil

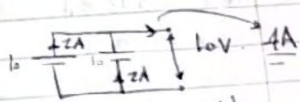
[Z]: number of conductors $Z = (2)(C)(N)$

[Single Layer Machine]: number of coils equal to half number of slots
coil per 2 slots

[Double layer machine]: number of coils equal to number of slots

Winding





Parallel current paths

Armature Winding of Dc-Machine

Lab winding $\left[a = mP \right]$

a: number of paths
P: number of poles
m: [m=1 simplex, m=2 doublex, m=3 triplex]

Wave Winding $\left[a = 2m \right]$

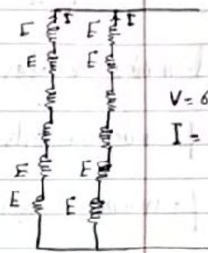
Ex: a DC machine have 24 slot, its a single Layer. Simplex Lab Winding and it has 2 poles

Single Layer $\Rightarrow$ 12 coil

simplex $m = 1$

Lab winding $a = mP = (1)(2) = 2$ paths

since we have 2 paths $12/2 = 6$ coil/path



$V = 6E$

$I = 2I$

b if number of Poles $= 4$, Same Lab winding, slot 24, single layer, simplex

- 12 coil
- $m = 1$
- Lab $a = mP = (1)(4) = 4$ Paths

$12/4 = 3$ coil/Pat

$V = 3E$

$I = 4I$

$P = IV = 12EI$

if $R_{coil} = 1\,\Omega$, $R_{path} = R_{coil} + R_{coil} + R_{coil} = 3\,\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{4}{3}$$

R_{path} R_{path} R_{eq}

$R_{eq} = \frac{3}{4}$

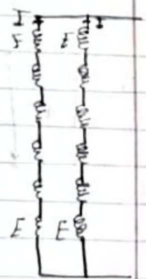
c if Single Layer Simplex Wave Winding, with 24 slot, 4 pole

Single $\Rightarrow$ 12 coil

Simplex $\Rightarrow m = 1$

wave $\Rightarrow a = 2m = 2(1) = 2$ Paths

$12/2 = 6$ coil/Path



$V = 6E$

$I = 2I$

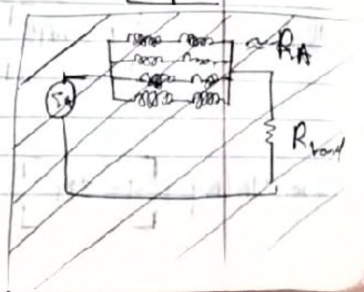
$$R_{eq} = \frac{R_{path}}{n_{path}}$$

Armiture Resistance :

$R_{conductor}$

$$\boxed{R_{turn} = 2\,R_{conductor}}$$

$$\boxed{R_{coil} = N_c\,R_{turn}}$$



Example: DC-generator, 4 poles, ~~xxx~~, 100 A, $\phi = 0.02$ Wb
10 turn per coil, 120 slots, Single layer, $R_{turn} = 0.01\,\Omega$, Semplex Lab

1- Determine Armeture Resistance
2- number of coils
3- number of paths
4- coil/path

2- Determine the induced Voltage [EA] if the generator speed = 1200 rpm

3- Determine the terminant Voltage of the generator Loaded by $R = 10\,\Omega$

4- Determine the Speed required for the generator to supply a Load of 20 KW and $V_T = 500$ V

5- if the flux Indused by 50% determine the new speed required for the generator to develop $E_A = 515$ V

$\boxed{1}$ $R_{turn} = 0.01\,\Omega$

$R_{coil} = (0.01) \times 10 = 0.1\,\Omega$

$R_{path} = (0.1) \times 15 = 1.5\,\Omega$

$R_A = \frac{1.5}{4} = 0.375\,\Omega$

$\frac{1}{R_{eq}} = \frac{1}{1.5} + \frac{1}{1.5} + \frac{1}{1.5} + \frac{1}{1.5} = \frac{4}{1.5}$

$R_{eq} = \frac{1.5}{4}$

$\boxed{R_A = 0.375\,\Omega}$

- 4 poles
- single layer
- 120 slot $\rightarrow$ 60 coil
- semplex $m = 1$
- Lab $= a = mP = (1)(4)$
  $a = 4$ paths
- 10 turn per coil
  $\frac{60}{4} = 15$ coil/path

$\boxed{2}$ $V_T = E - I_A R_A$, $E = K \phi \omega$

$$E = \frac{PZ}{2\pi a} \phi \, 1200 \, \frac{2\pi}{60} = \frac{(4)(2 \times 10 \times 60)}{2\pi (4)} \times (0.02) \times \frac{1200 \cdot 2\pi}{60}$$

$\boxed{E = 480\ V}$

Example: DC generator has 90 coils each coil with 4 turns Semplex Lab winding, P = 4 poles, if armuture Resistance $R_A = 0.5\,\Omega$ Determine the following if the $\phi = 0.04$ Wb

1- No Load Voltage if the generator Prime mover = 1000 rpm

2- Determine the Speed required the generator to Supplied at a Load of 4KW, $V_T = 500$ V

- 90 coils - 4 turn/coil - 4 poles
- Semplex $m = 1$
- Lab $a = mp = (1)(4) = 4$ paths
- $R_A = 0.5\,\Omega$
- $\phi = 0.04$ Wb
- $Z = (4)*(2)*(90) = 720$

E_A

[a] - at no Load $I_A = 0$, close to be zero so small to point that we can Ignore it

$$V_T = E_A - I_A R_A$$

$\phi = 0.04$ Wb

$$V_T = E_A = K\phi W \quad , \quad K = \frac{ZP}{2\pi a} = \frac{(720)(4)}{2\pi\,(4)} = 114.591559$$

$$W = (1000)\frac{2\pi}{60} = 104.7197551 \text{ rad/s}$$

$$V_T = E_A = (0.04)(114.591559)(104.7197551) \approx \begin{matrix} 479.99999 \\ 480\text{ V} \end{matrix}$$

[b] $V_T = E_A - I_A R_A$

$E_A = KW\phi$

$P_{Load} = V_T * I_A \qquad I_A = \frac{4000}{500} = 8_A$

$E_A = V_T + I_A R_A = 500 + (8)(0.5)$

$E_A = 504$ V

$$W = \frac{E_A}{K\phi} = \frac{504}{(0.04)(114.591559)}$$

$$W = \text{ans} \times \frac{60}{2\pi} = 1050 \text{ rpm}$$

[rev/min] [rad/s] إستعمال W في التحويل Δ

Example: A DC-generator wich have Simplex Lab winding with 4 poles.
$R_A = 0.25\,\Omega$ number of coils = 80 $Z = 640$ conductor

1- Determine Induced voltage E_A if the generator loaded by 3KW 150V

2- Determine the Speed required for the generator to supply load in case (1) if the flux is 0.02 Wb

3- Determine Induced torque for case 1 and 2

4- Determine (T_{app}) if the friction losses amounts to 100W

5- if the induced voltage $E = 160v$ and $R_L = 5\,\Omega$ Determine T_{ind}

$\boxed{0}$ $P = 4$ poles — $Z = 640$ conductor

Simplex $m = 1$ — $N = 640/(2)(80) = 4$ turns/coil

Lab — $a = mP = (1)(4) = 4$ paths

— 80 coil

— $\frac{80}{4} = 20$ coil/path

$\boxed{1}$ $E_A = K\phi W$ $P_{out} = I_A V_T$ $I_A = \frac{3000}{150} = \boxed{20\,A}$ I_A

$V_T = E_A - I_A R_A$ $E_A = 150 + (20)(0.25) = \boxed{155\,V}$ E_A 155V

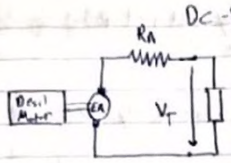
$\boxed{2}$ $W = \frac{E}{\phi K} = \frac{155}{(0.02)\left(\frac{640 * 4}{2\pi(4)}\right)} * \frac{60}{2\pi} = \boxed{726.5625}$ rev per minute (rpm) W

$\boxed{3}$ $T_{ind} = \frac{\overbrace{E^* I_A}^{P_{inp}\ \text{(?)}}}{W} = \frac{155 * 20}{726.5625 * \frac{2\pi}{60}} = \boxed{40.74\ N.m}$

OR $T_{ind} = K\phi I_A = 40.74$ N.m

$\boxed{4}$ $T_{app} = T_{ind} + \frac{P_{friction}}{W} = 40.74 + \frac{100}{726.5625 * \frac{2\pi}{60}} = \boxed{42.054\ N.m}$

DC-generator [generator electricity]



mechanical power ($T_{applied} * W$) → friction loss → electricall loss $[I_A^2 R_A]$ → P_{out} (electrical)

($P_{out} = V_T * I_T$)

$P_{out} = P_{developed} = T_{induced} * W$

$P_{in} = P_{loss} + P_{out}$

$E_A * I_A = P_{mech\ loss} + P_{out\ electric}$

$\boxed{T_{applie} = T_{input}}$ [*]

in generator
$T_{app} > T_{ind}$
$P_{app} > P_{ind}$
$P_{inp} > P_{out}$

$\boxed{W * T_{input} = P_{input}}$ [*]

$\boxed{T_{input} = \frac{P_{input}}{W}}$

$\boxed{T_{induces} = \frac{E_A * I_A}{W}}$

$\boxed{P_{developed} = T_{induced} * W}$ [*]

$T_{induced} = \frac{K \phi W * I_A}{W}$

$\boxed{T_{induced} = K \phi I_A}$

$\boxed{T_{induced} = T_{ind}}$

$W * T_{output} = P_{output}$

$\cancel{T_{induced} = \frac{P_{output}}{W}}$

$\cancel{T_{induced} = \frac{V_T I_A}{W}}$

القوانين هذي غالباً مش صحيحة

$P_{input} = P_{loss} + P_{output}$

$W\ T_{inp} = P_{loss} + \cancel{P_{output}}\ W\ T_{induce} \quad \div W$

$\boxed{T_{input} = \frac{P_{loss\ friction}}{W} + T_{induced}}$

$$\boxed{\frac{\tau_1}{\tau_2} = \frac{I_{A1}}{I_{A_1}}} \text{ if } K\phi \text{ constant} \ *$$

$$E_A = V_L + V_{load} = IR_L + IR_A = I_A(R_L + R_A)$$

5 $$I = \frac{E_A}{R_L + R_A} = \frac{160}{5 + 0.25} = \boxed{30.4\ A}$$

$$\tau_{ind} = \frac{P_{int}}{\omega} = \frac{E_A * I_A}{\omega} = \frac{K\phi\omega I_A}{\omega} = K\phi I_A = (0.02)(30.4)\frac{(640)(4)}{2\pi(4)}$$

$$\boxed{\tau_{ind} = 62.08\ N.m}$$

$$\tau_1 = K\phi I_{A1}$$
$$\tau_2 = K\phi I_{A2}$$

$$\frac{20}{30.4} = \frac{40.74}{\tau_2}$$

$$\boxed{\tau_2 = 61.9}$$

N.118

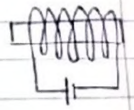
DC-Generator with field circuit

Permenent Magnet

* Flux (ϕ) not controlled

electro Magnet

* $\phi = \frac{MMF}{R} = \frac{NI}{R}$



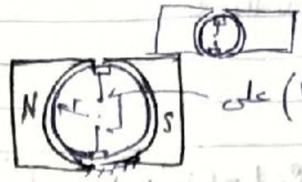
field circuit: where the flux produced in DC-Generator
Armeture circuit: where it deliver the current to the load

$$\phi \rightarrow I_f, \left[I_f\uparrow \Rightarrow \phi\uparrow,\ I_f\downarrow \Rightarrow \phi\downarrow \right]$$

N.118

$e_{ind} = 2VBL$

$A_p = \frac{2\pi r L}{2}$, area plain for one side N or S



لما تلف بتنتجه (Voltage) على

$rL = \frac{A_p}{\pi}$

$V = Wr$
Velocity

$e_{ind} = 2Wr^* B^* L$

$= 2WBrL$

$= 2WB^* \frac{A_p}{\pi}$

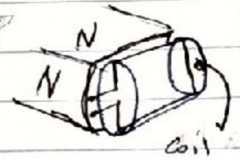
$e_{ind} = \frac{2^* W}{\pi} {}^* \phi$, ($K = \frac{2}{\pi}$ machine constant depend on the geometry of the machine)

$\boxed{e_{ind} = K \phi W}$

$K = \frac{ZP}{2\pi a}$

C: number of used coils

N_c: turn per coil



$Z = 2 C N_c$

P: pol number

$e_{ind} = \frac{ZP}{2\pi a} {}^* \phi {}^* W$

a: number of urrent pole

$Z = 2^* 1^* 1 = 2$, $K = \frac{2^* 2}{2\pi^* 1} = \frac{2}{\pi}$ ... لعت $\frac{\pi}{2}$ عشان هون فقط (coil 1

$P = 2$, $a = 1$

$\boxed{e_{ind} = K \phi W}$

$e_{in} = K^* \phi \cdot^* \frac{2\pi n}{60}$

$= \frac{ZP}{2\pi a} \times \phi \times \frac{2\pi n}{60}$

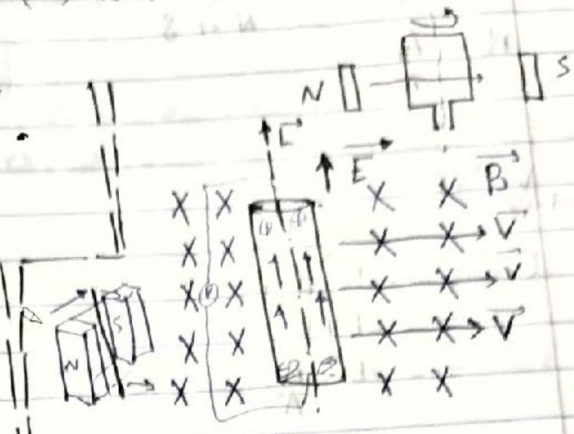
$= \frac{ZP}{60 a} {}^* \phi n$

$\boxed{e_{ind} = K' \phi n}$ $\boxed{K' = \frac{ZP}{60 a}}$

Electric rotating ~~mo~~ machine [Generator]

* e_{ind} = generated Voltage

* ال (turpine) في محطة كبير نوعاً ما بيعطينا (1MW)



Gen Induced

Generator action $e_{ind} = (\vec{V} \times \vec{B}) \cdot \vec{L}$
cross product

$\vec{E} = V.B.\sin\theta_{VB}$

$\theta_{VB} = 90^\circ \longrightarrow E = VB$

$E = \left[\frac{m}{s} \frac{Vs}{m^2} = \frac{V}{m}\right]$

$B\left[\frac{Vs}{m^2} = \text{Tesla}\right]$

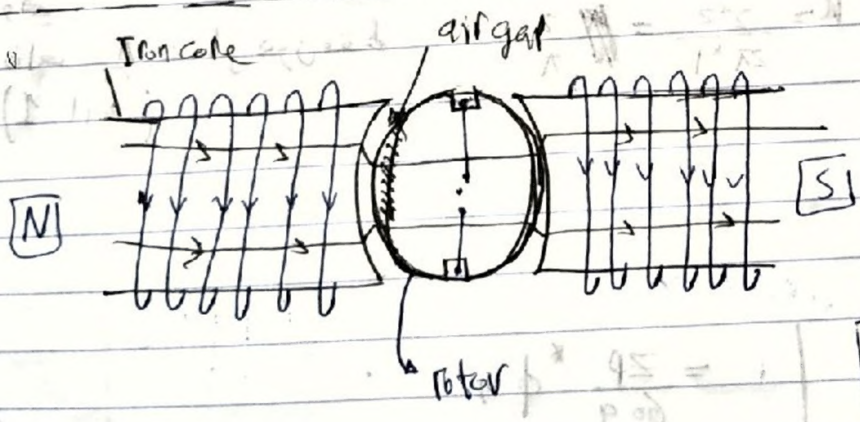
E: electric field

$\vec{E}.\vec{L} = E\,L\cos\theta_{EL} = EL = \frac{V}{m} \times m = V$ ($\cos(0) = 1$)

$V\left[\frac{m}{s}\right]$

$q_e = -1.6 * 10^{-19}\ As$

$\vec{F} = q * \vec{E}\ \left[As^* \frac{V}{m} = \frac{Ws}{m} = N\right]$



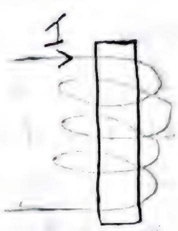
~~Relactang~~
Relactance Iron
Relactance air

$\boxed{e_{ind_T} = 2VBL}$

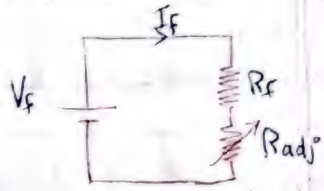
e_{ind}
(ab): VBL (Bc) = 0 (cd): V_bL (da) = 0 $\sum e_{ind_T} =$

Shunt $\xrightarrow{\text{معناه}}$ Pallel

* fulx {
- Permament magnet → un Contorlled
- elector magnet → contorlled



* field circuit :



$$\phi = \frac{MMf}{R} = \frac{NI}{R}$$

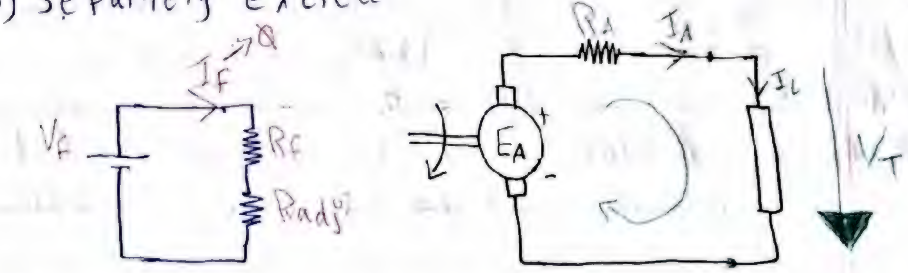
$$I_f = \frac{V_f}{R_F + R_{adj}}$$

(التحكم بـ ϕ

إذا كانت صفر
يكون الـ If Max

* DC - genertors types

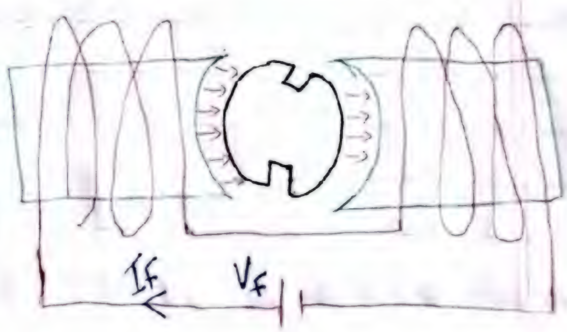
1) separtely excied

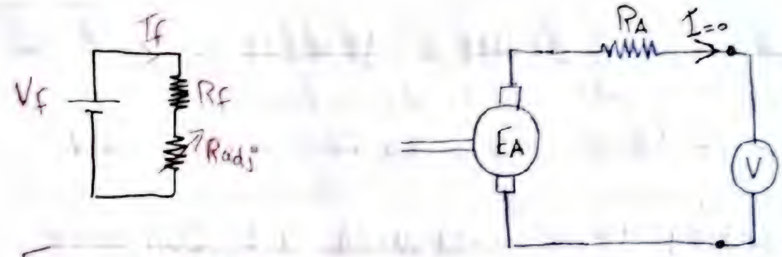


$$I_f = \frac{V_f}{R_F + R_{adj}}$$

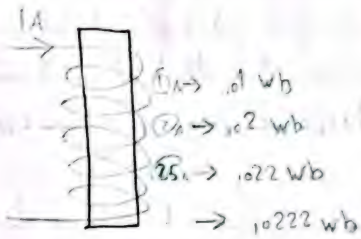
$$E_A = V_T + I_A R_A$$

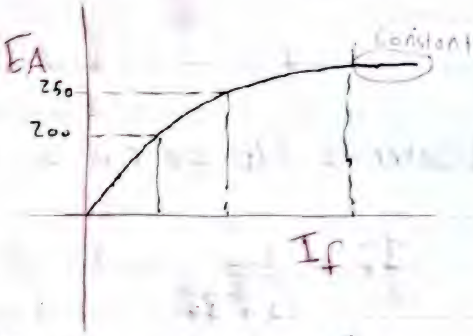
$$I_L = I_A$$





$$E_A = K \phi \omega$$





Ex:

$E_{A1} = 100\,V$, $I_f = 1A$, $n = 1000$ rpm

$E_{A2} = ??$, $I_f = 1A$, $n = 1500$ rpm

اقسم اعلى 2

$$E_{A1} = \cancel{K} * \cancel{\phi} * n_1 * \cancel{\frac{2\pi}{60}} = 100$$

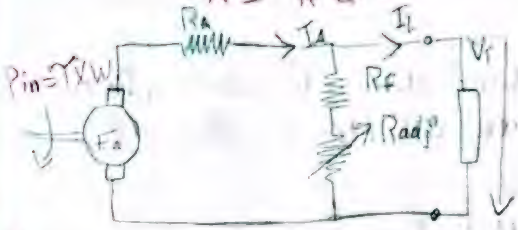
$$E_{A2} = \cancel{K} * \cancel{\phi} * n_2 * \cancel{\frac{2\pi}{60}} = ??$$

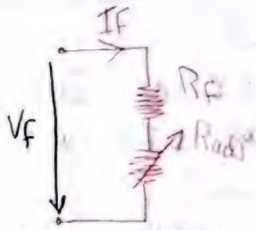
$$\frac{100}{E_{A2}} = \frac{n_1}{n_2} \Rightarrow E_{A2} = \frac{100 \times 1500}{1000} = 150\ V$$

E_A , R_{adj} , n يكون معطينا إثنين منهم ونطلع الثالث

* self excited DC - generator

$E_A = K\phi\omega$





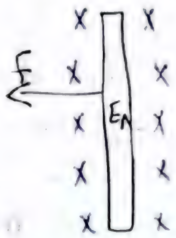
* Shunt generator

$P_{deve} = E_A \times I_A = I_A^2 R_A + I_f^2 (R_f + R_{adj}) + P_{out}$

$V_T = E_A - I_A R_A$

$I_A = I_L + I_f$

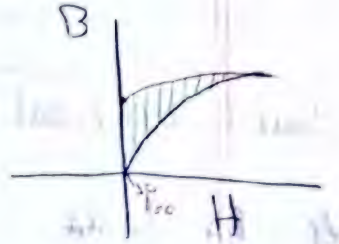
$I_f = \frac{V_T}{R_F + R_{adj}}$



Residual flux

ϕ بكون قليل

بس ما بساوي صفر



$H = \frac{NI}{l}$

9:27 AM 4.5KB/s

DC - shunt generator with $\eta = 80\%$
$P_{inp(mech)} = 5\,KW$, $V_T = 100\ V$, $R_f + R_{adj} = 100\ \Omega$

$R_A = ,5\ \Omega$, speed $= 1400$ rpm

1) Detrmine developed power

$$P_{out} = 5000 \times ,8 = 4000\ \text{watt}$$

$$I_L = \frac{4000}{100} = 40\ A$$

$$I_f = \frac{V_T}{R_f + R_{adj}} = \frac{100}{100} = 1\ A$$

$$I_A = I_L + I_f = 40 + 1$$

$$P_{deve} = E_A * I_A$$

$$E_A = 100 + 41 \times ,5 = 120,5\ V$$

$$P_{deve} = 120,5 \times 41 = 4940,5$$

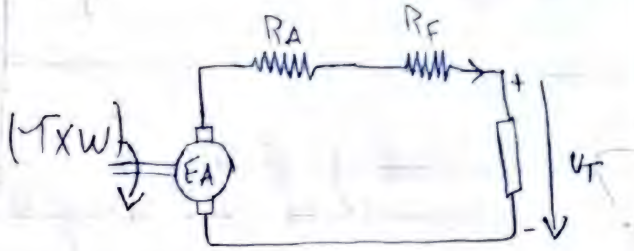
$$T_{ind} = \frac{P_{dev}}{\omega} = \frac{4940,5}{1400 \times \frac{2\pi}{60}} = 33,7\ N.m$$

$$T_{app} = \frac{5000}{1400 \times \frac{2\pi}{60}} = 34,1\ N.m$$

Ibrahem H Kojok
JUL 10 AT 6:11 PM

Like Comment

2) series DC generator



$V_T = E_A - I_A R_A$ $\qquad$ $I_A = I_L = I_f$

$I_L\uparrow = I_A\uparrow = I_f\uparrow$ → $\phi\uparrow \Rightarrow E_A\uparrow \Rightarrow V_T\uparrow$

$I_L\uparrow = I_A\uparrow = I_f\uparrow$ → $-I_A(R_A+R_f)\uparrow \Rightarrow V_T\downarrow$

E_A	I_A	V_T
110 V	10 A	100 V
150 V	15 A	$150 - 15 \times 1 = 135$ V

$(R_A + R_s) = 1\,\Omega$

50 turns

10 turns

E_A	I_A	V_T
100 V	10 A	90 V
105	15 A	$105 - 15 \times 1 = 90$ V
108	20	$108 - 20 \times 1 = 88$ V

* Armature reaction في ال generator يقلل الفلكس

if Armature reaction is not compeusated is not negleeted

$$I_f^* = I_f - \frac{AR}{N_f}$$

sep excited	Shunt	Series
$I_f = \frac{V_f}{R_f + R_{adj}}$	$I_f = \frac{V_T}{R_f + R_{adj}}$	$I_f = I_A = I_L$
$I_f^* = I_f - \frac{AR}{N_f}$	$I_f^* = I_f - \frac{AR}{N_f}$	$I_f^* = I_f - \frac{AR}{N_f}$

Compound

$$I_f^* = I_f \pm I_A \frac{N_s}{N_f} - \frac{AR}{N_f}$$

* EX: sep excited DC generator with magnetization table as follow
$R_A = ,2\ \Omega$, $R_f = 20\ \Omega$, $N_f = 800$ turns , $V_f = 100$ V

1800 rpm

I_f^*	1	2	2,3	2,5	2,7	2,9	3	4	A
E_A	40	80	87	91	96	97	99	120	V

1) Detrmine V_T at no load condition , $n = 1700$ rpm
$R_{adj} = 20\ \Omega$

في حالة الـ no load

الـ If هي نفسها I_f^*

$V_T = E_A$ at no load

$$I_f = \frac{100}{20+20} = 2,5\ A$$

$9,1 \longrightarrow 1800$ rpm
$?? \longrightarrow 1700$

$E_A = 85,9$

2) Detrmine Voltage regulation if out put current = 20 A
AR = 100 A.turns , Speed = 2000 rpm , $R_{adj} = 20\ \Omega$

* full load (20) A

AR at no load = 0

$$I_f = \frac{100}{20+20} = 2,5\ A$$

$I_f^* = 2.5 - \frac{100}{800} = 2.3\ A$

$87 \leftarrow 1800$
$E_A \leftarrow 2000 \Longrightarrow E_A = 96.6\ V$

$V_T = 96.6 - 20 * .25 \Longrightarrow 91.6$

V_T (no load) $n = 2000$ rpm

$I_f = \frac{100}{20+20} = 2.5$

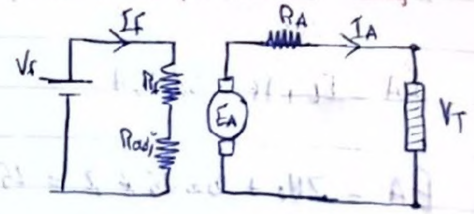
$I_f^* = I_f - 0 = 2.5$

$91 \leftarrow 1800$
$E_A \leftarrow 2000 \Longrightarrow E_A = 101.1\ V = V_T$

$VR = \frac{101.1 - 91.6}{91.6} * 100\% = 10\%$

3) If the generator has an armature reaction $AR = 100$ A.turns
$I_{load} = 40\ A$, $n = 2000$ rpm, $V_T = 100\ V$, Determine R_{adj}

$E_A = 100 + 40 \times .25 = 110\ V$



$110 \longrightarrow 2000$ rpm
$E \longrightarrow 1800 \Longrightarrow E_A = 99\ V$

$218 \rightarrow 1700$
$251,39 \rightarrow n$ $\Longrightarrow n = 1960,38$ rpm

* With AR $\Rightarrow$ 2000 A.turns

$I_f^* = 1 - \frac{200}{1000} = ,8$ A

$215 \rightarrow 1700$ rpm
$251,38 \rightarrow n$ $\Longrightarrow n = 1987,7$ rpm

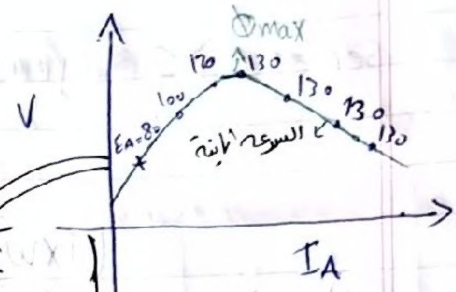
b) Determine rotational losses, applied torque induced torque for Cas(a)

Without AR:

Rotation losses = Pinp − Pout − elect losses
= Pinp − Pdev
= $20 \times 746 - (251,39 \times 56,95) = 603,4$ watt

$T_{app} = \frac{P_{inp}}{\omega} = \frac{20 \times 746}{1960,38 \times \frac{2\pi}{60}} = 72,7$ N.m

$T_{ind} = \frac{E_A \times I_A}{\omega} = \frac{251,39 \times 56,95}{1960,38 \times \frac{2\pi}{60}} = 69,7$ N.m



(Charcteristic curve of DC series generator)

Ex: DC_series generator $\eta = 90\%$, $P_{inp} = 10\ hp$

$V_T = 200$ volt, $n = 1000$ rpm

Detrmine developed Power, T_{ind}, $T_{applied}$

$P_{inp} = 746 \times 10$ watt

$P_{out} = .9 \times 746 \times 10$

$V_T = 200$

$$I_L = \frac{.9 \times 746 \times 10}{200} = I_f = I_A$$

$E_A = 200 + I_A(1.6) \Rightarrow$

1) $P_{dev} = E_A \times I_A$

2) $$T_{ind} = \frac{E_A \times I_A}{\omega} = \frac{E_A \times I_A}{1000 \times \frac{2\pi}{60}}$$

3) $$T_{app} = \frac{10 \times 746}{1000 \times \frac{2\pi}{60}}$$

4) friction losses

$P_{inp} - P_{dev}$